CHBE/MSNE 416/516 001 Sp19

Syllabus MSNE 416/516

STRUCTURE AND PROPERTIES OF

POLYMERS AND SOFT MATTER

Class will regularly meet on Tu, Th from 10:50am -12:05pm in Herman Brown Hall 427

Perspective

This graduate level course (also available to undergraduates by permission) addresses the fundamental structures and properties of polymers and other forms of soft matter (gels, colloids, nanoparticles, etc) and their many roles as technologically important materials. The mechanical, optical, transport, acoustic and electrical properties are presented with respect to the underlying physics and engineering.

Topics include structures in thin films, effects of nanoscale on properties, processing via 3D printing, with light, electrons and ion beams (including interference lithography, directed self assembly of systems of soft materials for metamaterials, actuation and sensing). Examination of the structure of noncrystalline, liquid crystalline and crystalline material states using electron microscopy and X-ray diffraction techniques. Relationships between structure and function in soft matter systems. Frequent in class demos!

Learning Goals

- To understand the role of weak interactions (of the order of the thermal energy, kT) on the molecular level arrangements of soft matter and to be able to reason out the likely molecular level response(s) to a host of different stimuli.
- To understand the principal types of atomic and molecular structures in the noncrystalline (rubbery and glassy), liquid crystalline and crystalline states.
- To be able to relate how the physical properties of soft matter arise from their structures and how various processing techniques can alter the structures and hence the resultant properties. Such understanding provides key insight into structure-processing-properties-performance relationships.

- To be able to apply transmission and scanning electron microscopy as well as X-ray diffraction techniques to elucidate soft matter structures at the atomic to mesoscale.
- To utilize the properties of soft matter in order to be able to design useful engineering materials for a host of technological applications involving multiple desirable functions.
- To learn how to communicate clearly these concepts via oral and written presentations.

Grade Basis

There will be biweekly problem sets that will contain ~ 4-5 questions for students to work and turn in for a grade and an in-class mid-term exam and a final exam during exam period. Students will each consult with the instructor and pick an individual topic in soft matter to research and write a 10 page paper (plus figures and references). Grading will be determined by a combination of problem sets (35%), an in-class midterm exam (25 %), the written 10 page report(15%), and the final examination (25%). Extensions on problem sets will be given only in limited circumstances. Homework will normally be due in class on a specific date.

Instructor

Professor Ned Thomas, Materials Science and NanoEngineering.

Office George R. Brown Hall East - room 200J. Phone: 713- 348-3806

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Textbook and Resources

Textbook: none required

Useful Reference Textbooks:

Robert J. Young and Peter Lovell, “Introduction to Polymers”

D.F. Evans and H. Wennerstrom, “The Colloidal Domain”

I.M. Hamley, “Introduction to Soft Matter”

Many pdfs of topics will be made available.

Course Website and Online Resources

Course content will be posted on Canvas (https://canvas.rice.edu/courses/). This site will be used to make announcements and post handouts, homework assignments, lecture notes, and grades. All students registered for the course should automatically have access to this site. Professor Thomas will regularly check the website and respond to comments and questions posted. Thomas is also keen on verifying that you access the website to access the class notes, psets and various handouts.

Honor Code Policy

Please work independently on homework problems. Use of the course blog to make queries about psets, or asking questions in class or at office hours is encouraged. Copying is strictly forbidden. Any discussion or collaboration on examinations is also forbidden. Information about the Rice Honor System can be found at http://honor.rice.edu/

Accommodations

Any student with a documented disability seeking academic adjustments or accommodations is requested to speak with Professor Thomas during the first two weeks of class. Students with disabilities can also contact Disability Support Services in the Ley Student Center.

Tentative Schedule of Lecture Topics and Exams

January 8	Introduction to Soft Matter
January 10	Molecular Conformations, Sizes and Shapes
January 15	Ideal Chains in Theta Solvents, Entropies
January 17	Thermodynamics of Mixtures: Solutions and Blends
January 22	Viscosities of Solutions and Melts
January 24	Characterization I – Scattering from Solutions and Melts
January 29	Glassy State and Tg
January 31	Diffusion and Reptation

February 5	Rubbery State, Gels, Foams
February 7	No Class Spring Recess
February 12	Liquid Crystalline State – orientational order
February 14	Crystalline State and Chain Folding
February 19	Spherulites, Nucleation and Growth Kinetics
February 21	Characterization II – Diffraction from Ordered Assemblies
February 26	Self Organization – Micelles, Ternary Phase Behavior, Colloids
February 28	Block Polymers, Directed Self Assembly
March 5	**In Class Exam**
March 7	No class APS meeting!
March 12	No class Spring Break
March 14	No class Spring Break
March 19	Characterization III – SEM and SVSEM
March 21	Characterization IV – TEM, STEM and CryoTEM
March 26	Processing Methods including fibers
March 28	Processing – Property Relationships, Nanocomposites
April 2 and Scale	2D Materials, Multifunctionality and Designing Using Symmetry
April 4	Optical and Electrical Properties
April 9	Mechanical Properties, Recycling, Energy from Plastics
April 11	3D Printing and Lithography
April 16	Photonics, Phononics
April 18	MetaMaterials and the Future of Soft Matter

Exam Period is April 25 – May 2 **Final Exam to be announced**